The Bioethanol Data Reference System

Development and Initial Implementation

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Table of Contents

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1.0 Introduction and Summary

1.1 Introduction

The Bioethanol Program of the Office of Fuels Development in the United States Department of Energy uses and produces a very large amount of information from diverse sources. There are also many different and geographically dispersed participants in the program, as well as a wide variety of stakeholders, who desire accurate and detailed information about the program and its results. There is a clear need for an organized process for the management and dissemination of program information. This report describes the initial steps in the development and implementation of such a system, which is referred to as the Bioethanol Data Reference System (BDRS).

The primary focus of the proposed data structure is the production and use of bioethanol (ethanol derived from non-food "cellulosic" biomass) for application as a transportation fuel and/or fuel additive in the United States. Because such production and use exists in a broader context, however, the information content of the BDRS does need to include some recognition of relevant international activities (e.g., the production and use of bioethanol in other countries) as well as relevant competing uses for the biomass (e.g., the production of electricity through "biopower" technology).

Similarly, there are competing concepts to meet the future needs of the United States transportation system. These include different fuel materials as well as vehicles and systems that differ in important ways from today's fuels and internal combustion engines. The economic attractiveness of such competitors depends in a number of cases on the cost and availability of conventional fuels, i.e., on the performance over time of the World Oil Market.

It soon becomes clear that there are important decisions to be made regarding the scope of a data reference system, the degree of detail which it incorporates in any given section, and how crosscutting subject matters are to be organized so that information can be rapidly accessed, understood, and used with confidence.

Another major set of considerations that affect the design and use of the system may be described as business management considerations. How does information get selected and validated for inclusion in the system? When and how does information get upgraded and/or purged from the system? Considerable amounts of scientific and technical information are subject to controversy as to their correct interpretation or application. What process might be used by the Bioethanol Program to develop a consensus position in these areas prior to including such information in the BDRS?

Finally, the design and content must be appropriate for the intended users and suitable for the intended means of distribution. On the one hand, it is critical to assure technical validity; on the other hand, excessively complex presentations can become a barrier to effective communication with desired audiences.

These and many other issues have been considered in the development and initial implementation of the BDRS. Brief treatments of the proposed system design criteria and then the recommended specific structure (with illustrative data elements) are presented in the next two subsections of this Introduction and Summary. Some next steps to progress system development are suggested as a final element. The main body of the report (beginning with section 2.0) expands the treatment of each of these three aspects in turn (design criteria, specific structure, next steps) in individual chapters in order to provide a more detailed understanding of the concepts involved.

1.2 Development – Design Criteria

The primary purpose of the BDRS is to communicate needed information that is accurate, consistent and understandable.

The intended primary users are the team participants in the United States Department of Energy's Biofuels Program analytic process. Secondary but equally important users will be interested members of the public and potential future program participants.

To achieve this purpose, and to satisfy these users, will require system design components which emphasize information standardization, consensus development among the participating analysts, data control for completeness and timeliness, and ready access to encourage continuing use and reliance upon the system to meet real time information needs.

Other information sources exist such as technical reports and reference books as well as electronic databases. The BDRS is intended to be synergistic with such tools rather than competitive. While technically accurate in its summary of reference materials, it will direct the user to the original sources for details. Unlike databases, the emphasis of the BDRS will be on insights, discussion, understanding, and illustrative material in addition to facts.

Initially, a number of design issues were considered, and proposed design criteria adopted.

Consideration of scope and depth lead to the views that:

- While the primary focus of the BDRS is on the production and use of bioethanol in the United States, such focus must be placed in an appropriate international and marketplace context;

- Information in the BDRS must be technically accurate, but its presentation must be understandable to a broad range of users; and

- Individual elements of information should be free of technical jargon, and disaggregated into, and presented as, small units for ready assimilation by users.

These considerations lead to the concept of a large structure with many individual elements. Other structural design elements follow self-evidently from these premises. There is a clear need for standardization of treatment and consistency of design throughout for ease of use. Other aspects support the ability to maintain, upgrade and modify the structure over time. Still other criteria speak to the interrelationship among the BDRS and other data sources. There is no desire to be encyclopedic; however, there is a need for sufficiency of coverage

and the provision of accurate understanding of relevant areas of information. Most design elements follow directly from consideration of either the purposes of the BDRS or the needs of its intended users.

The total BDRS system includes more than its structure, categories and information content. It also includes the business management considerations used to control its data input procedures, to distribute the information, and to maintain and upgrade the system and its content over time.

This discussion presumes that managerial responsibility for the BDRS is assigned to the National Renewable Energy Laboratory (NREL). Personnel at NREL and other analysis team participants either propose concepts for BDRS entries to NREL (within the established structure and categories) or submit draft entries to NREL. NREL is then responsible for managing the next steps in the process. Specific procedures are proposed for assuring the technical accuracy of the final version of the entry, achieving consensus on specific issues when required, and resolving any conflicts and/or controversial matters. Additional review requirements are noted: to meet consistency standards (relative to other entries), by mandating bibliographic, version control, and interpretive requirements (as set forth in the design criteria); and to satisfy the overall objective of the system to communicate effectively.

The proposed business management procedures are specifically designed to decentralize responsibility among analysis team participants, to make dispute resolution and internal peer review procedures integral to the system (but only calling upon them on an as-required basis), to assure that no single participant can exert undue influence on the system content, and to recognize the final resolution authority and responsibility of the federal head of the Bioethanol Program at the Department of Energy's Headquarters location.

Additional responsibilities of a housekeeping nature are also defined for the NREL BDRS Business Manager. These include the maintenance of the system, the distribution of its information content to users and the establishment of feedback mechanisms to ensure that system objectives are being met.

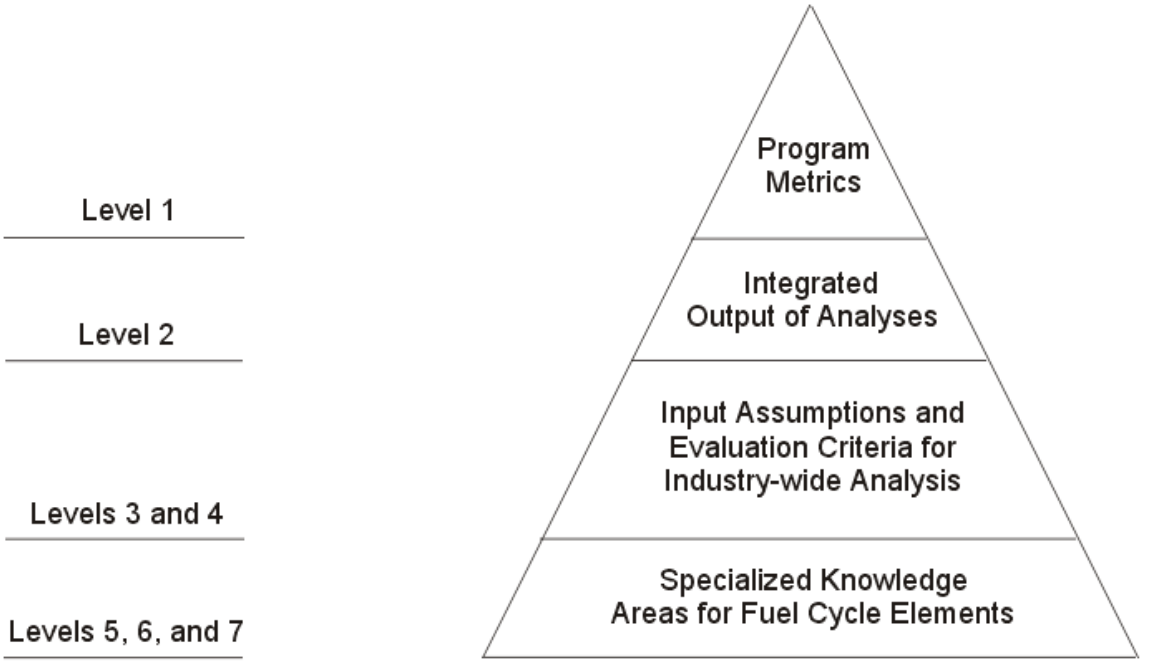
Based on the design criteria and business management considerations summarized above, a specific structure, categories, and distributional approach has been developed for the initial implementation of the BDRS.

1.3 Implementation – Specific Structure

The proposed hierarchical structure of the BDRS is presented in Figure 1. In triangular form, it builds from a base of specific details of the various fuel cycle elements involved in the production and use of bioethanol to the program management aspects at its apex. This Triangle of Analysis for Bioethanol is discussed in detail in the main body of the report. It is referred to here as eTAB! in order to stress its electronic basis, and to support the ease with which spreadsheet tabs (or the equivalent HTML links) may be scanned in order to readily find specific pieces of information.

The BDRS structure is implemented in eight Microsoft Excel™ files attached to this report. These correspond to an institutional program metric level 0 (not shown in Figure 1) and the seven information content levels making up the information triangle.

Figure 1
Structure of eTAB!



Each level contains two to four Categories that are, in turn, subdivided with Topic Areas associated with these Categories. Each Topic Area is a separate spreadsheet page and is identifiable by a tab that contains its name. Each such page may contain numerous individual Information Entries.

The individual Information Entries are the building blocks of the BDRS. Hence they may be stored, periodically updated and distributed on disk media or by email. Alternatively, the tree-like structure (Categories and Topic Areas) may be used to hang the Information Entry ornaments for ready searching and location on an Internet Website. In that case, access may have to be controlled to some of the information elements that may be sensitive or may represent work in progress not yet suitable for general distribution to all potential users.

A full listing of all structural elements (Levels, Categories, and Topic Areas) is presented in Appendix A to this report.

While originally conceived as a fixed medium (disk-based) system, a system status review meeting of potential users on October 7, 1999, resulted in a strong consensus for a Web-based system. The system presented in this report has been analyzed to verify that it is completely suitable for such an approach. The Web-based system has the superior attributes of greater ease and frequency of update and of remote access. The latter characteristic, however, introduces certain new issues concerning the ability of the user to interact remotely

with intended illustrative types of information modules. These issues have been researched as part of this study, problems identified, and solutions proposed. The recommendation of this report is that the BDRS employ the available leading edge technologies for Web-based systems that are identified in the body of the report.

Illustrative Information Entries are described (and included as part of the electronic files attached to the report). These are summarized by Level, Category and Topic Area in Table 1. They are selected to extend from text only, through primarily quantitative and/or graphic, to fully interactive (responsive in real time to user commands), such that the full potential of the system can be better visualized.

Abbreviations used in the entries have been listed in the Level 0 workbook and appropriate Overview and Bibliographic entries included in their proper locations.

The interactive information entry on Conversion will be placed in February 2000 on the TMS Website (tms-hq.com) as an illustration of Web functionality for an entry of this type.

1.4 Next Steps

The experience of designing a structure and preparing illustrative information entries for it indicates that the BDRS is a feasible concept, and offers considerable value for its future users. Information in the BDRS should find ready use in program outreach materials, analytic studies and reports, speeches and presentations, strategic and program plan development, the selection of related metrics, and the tracking of program milestones. This information can be current, well organized, easy to locate, available on a quick response basis, and already validated through peer review.

The report presents a brief roadmap of desirable near-term decisions and actions. An important set of recommendations are based on the view that NREL should manage the system through a Web-based delivery mechanism and that immediate efforts should be directed at continuing to expand the available validated information entries. Priority areas for this activity are suggested.

It is emphasized that individual entries are expected to be brief treatments, similar to the illustrative material already created. However, over time, the accumulation of numerous entries will gradually result in the existence of an impressive body of interconnected information, easily accessible by a wide range of users.

2.0 Development

2.1 Introduction

This chapter first discusses the perceived purpose and intended users of the Bioethanol Data Reference System. This discussion includes consideration of how this system relates to and/or differs from other managed sources of information concerning bioethanol. Next, various issues that impact the design and structure of the system are noted, and appropriate design criteria are proposed. Finally, the operational context of the system is considered, leading both to some additional design criteria and to proposed business management procedures.

Table 1
Illustrative Information Entries

Key to Table

Level and Category
Topic Area
Information Entry
Type of Entry

Entries

0 – Appendices
Analytic Models
Brief Descriptions of Models
Text

1 – Strategic and Program Plans
Missions and Objectives
Headquarters Strategic Plan
Text

2 – Program Analysis of Market Development
Penetration by Date and Use
Study Cases for Emerging Ethanol Industry
Text, Tabular, Graphics

3 – Monetization of Costs and Benefits
Rural Revenues
Rural Revenue from Reference Study Cases
Text, Tabular, Graphics

4 – World Context Indicators
Oil Market Projections
Annual Energy Outlook Projections
Text, Tabular, Graphics

5 – Economic and Financial Factors
Inflation and Discount Rates
Gross Domestic Product (GDP) Deflators
Text, Tabular, Graphics

6 – Feedstock Production and Delivery
Energy Crops
Crop Rotation and Harvesting Cycles
Text

7 – Conversion
Process Costs
Cost Variability
Text, Tabular, Graphics, ***Interactive***

8 – Demand and Use
Neat Fuel
Aviation Grade E85
Text

2.2 System Purpose and Intended Users

The primary purpose of the BDRS is to communicate information that is accurate, consistent and understandable.

The intended primary users are the team participants in the United States Department of Energy's Biofuels Program analytic process, together with their information sources and peer reviewers in other governmental entities, industry and academia.

At the same time, accurate public awareness and understanding of program goals, costs and benefits are critical to achieving an informed discussion of the emerging biofuels industry. Therefore, an important subsidiary purpose of the BDRS is to provide information in a form that can also be accessed and understood by an interested public, as well as potential future program participants.

These purposes, and the intended interaction with primary and secondary users, lead to an important subset of system design objectives.

First, it is essential that information be standardized and controlled as to its accuracy and/or its acceptability for use as a basis for analysis within the program. Typical matters for standardized treatment include:

- Default input assumptions for analyses.
- Key analysis results, particularly those which support major programmatic insights.
- Quality metrics resulting from analytic outputs, and insights, such as program goals and future milestones.
- Statements of program accomplishments and benefits.
- Information as to how key calculations are made.

In many cases, both inputs and outputs reflect substantial uncertainties and judgements. Accordingly, there may often be multiple sets of data to be reported and examined as to how and why these sets differ among themselves. Thus, even multiple versions of the same information need to be treated in a standardized fashion.

Second, when valid alternatives exist for analytic assumptions, it is necessary to establish some degree of consensus among analytic team participants as to the choice of a reference data set, and/or the proper use of valid alternatives to such reference information.

Third, revised (and presumably better) information becomes available with the passage of time. Older information needs to be purged periodically from the system and replaced with later versions. Completeness is also important to assure analytic balance. The existence of the system, and the procedures used to manage it, provide a valuable means of controlling both when and how information is revised, and also the selection of a default version of information from among competing data sets.

In addition to the system sub-objectives of information standardization, consensus development and data control, the fourth major element is that of providing a means to facilitate rapid data access. Unless the system is easy to access and to use, it will not achieve wide acceptance. On the other hand, ready access to reliable information should attract users and support the primary purposes of the system.

A final perspective on how the system is intended to relate to its target users may be derived by considering its coexistence with many other data sources, both printed (e.g., technical reference books and reports) and electronic (e.g., searchable databases). Clearly, it is wasteful of scarce resources to duplicate information that otherwise meets all the requirements of the BDRS itself. In such cases, the role of the BDRS would most appropriately be to summarize key information and insights, and then to direct the user to the more extensive original information.

The BDRS and other information sources are intended to be synergistic rather than competitive. The BDRS is to be technically accurate, and therefore useful to technical analysts. However, for deeper levels of detail, the analysts will be referred back to the original technical sources. The BDRS will contain information, as in a database, but the format will be much more flexible, and the emphasis will be on understanding and insights more than on raw and uninterpreted data. To aid understanding, the BDRS will need to include insights and other judgmental statements, in addition to data, and to include illustrative material in addition to facts.

2.3 Design Issues and Design Criteria

The first design issues (or decision areas) for the system are scope and depth.

By definition, the focus of the BDRS is on bioethanol in the United States. However, this topic must be placed in context; hence, the system scope must include material which addresses selected international aspects. The other aspect of context and therefore scope is the recognition that bioethanol must compete with other possible sources of ethanol, and that cellulosic feed materials which are used to make bioethanol may themselves be competed for by other possible application areas.

With respect to depth, the intended users comprise those with varying degrees of technical capability. It is also true that an expert in one technical area is not necessarily of equal technical depth in all areas. The criteria adopted here, therefore, are that information must be technically accurate, but its presentation must be understandable to a broad range of users. Accordingly, highly technical terms, acronyms, and specialized use of language should be avoided or clearly explained. Furthermore, the individual elements of information within the BDRS need to be disaggregated into, and presented as, small units, so that they may more readily be assimilated.

These first considerations lead to the concept of a large structure with many individual elements. However, this structure must be intuitive to use, and individual elements must be easy to find. At this point the conceptual structure might be seen as a large mobile, with overall topics and summary presentations at the top, dividing sequentially into subelements as one descends to the base of the mobile (or of individual subelements). At the base is the greatest level of detail and range of treatment.

Once this general approach is established, many of the design criteria concerning structure become almost self-evident:

- Choose the details of the structure and Category elements within the structure with the characteristics and needs of users in mind.
  - The basic structure should correspond to the decentralization of expertise that exists within and across the Bioethanol Program team participants, thus simplifying the selection and validation of appropriate information for inclusion in the system.
  - The category elements should be chosen to highlight both the interest in specific fuel cycle steps for the production of bioethanol, and alternative applications and devices for its use, as well as the need to address numerous cross-cutting issues and areas which exist independently of such specific fuel cycle elements or applications.
  - Allow for easy later expansion or contraction of depth and/or scope within the structure and its elements, as future conditions may warrant.
- Design the structure and related category elements for minimum cost maintenance and upgrading over time, consistent with performance requirements.
- Because of the presumed size of the structure and large number of small elements, establish standards of consistency throughout the structure and across all of its diverse elements.
  - Require multiple defined sublevels for expanded degrees of detail.
  - Require similar meanings for similar sublevels regardless of the individual category.
  - Require standardized inputs and uniform formats for data completeness.
  - Require uniform terminology and standardized units for related topics throughout the structure.

As previously noted in Subsection 2.2, balance and synergism with other information sources is desired. As a result, the design criteria for the BDRS in this area are:

- Avoid inclinations to be encyclopedic; accurate understanding of an information area is the objective.
- Extensive incorporation of data in support of understanding is most acceptable where the information source is a product of an analysis team participant of the Bioethanol Program, since output products of one participant are often input assumptions for another.
- Information readily accessible elsewhere may also be reported in the BDRS when it is needed for a discussion and/or comparison of competing data sets, or for similar purposes.
- Certain select information which is normally extracted from extensive compilations prepared by others (such as the Energy Information Administration's

projection of future energy use and prices in its Annual Energy Outlook volumes) will also be included in the BDRS for ease of access, because of its frequent use by analysis team participants.

Individual entries in the BDRS are expected to consist primarily (either singly or in combination) of (1) discussion, (2) quantitatively-based insight, (3) the numerical information itself in an interpretive context, or (4) illustration which incorporates an interactive component with the user. (The latter category will be explained more fully in Subsection 3.3 of this report.) An important design criterion for the presentation of content is as follows:

– Maximize the ability to show the user (and validate): how quantitative results are calculated, the visual (graphic) characteristics of the information, and the comparative and sensitivity aspects of the information.

Finally, as an aid to standardizing, controlling, and verifying the accuracy of information, and helping to assure its proper use:

– Include the following information for all entries:

  - A bibliographic reference to the original data source(s).
  - The date of the information (if known and different from the date of the source(s)), and the reference year applicable to any economic data included.
  - A version control notation which advises users as to when the information in this subsection was created or last revised.
  - A brief notation (or longer discussion, if warranted) of any relevant data issues.

The total BDRS system includes not only the structure, categories and information content, but it also includes the techniques used to manage, maintain and upgrade this collection of information. The business management considerations are the subject of the next subsection.

2.4 Business Management Considerations

The structure and names of the categories of topics within the BDRS are initially fixed by the system's design. The content of the BDRS, however, is in its individual entries. There will likely be many separate entries for each category. These must be prepared one-by-one, and validated for acceptance into the system. There must be formal procedures to manage this process.

This discussion presumes that managerial responsibility for the BDRS is assigned to the National Renewable Energy Laboratory (NREL). Personnel at NREL and all other analysis team participants are free to either propose a concept for an entry to NREL, or propose and submit to NREL a draft version of an entry (new or revised) for the BDRS. If a concept entry is proposed, the BDRS Manager at NREL will select a specific team participant to prepare a draft entry. In any event, the entity that finally prepares the draft has the responsibility to assure the technical accuracy of the entry and/or its acceptability to other team participants with equal knowledge in the subject technical area, and to affirm that this requirement has been met as part of its submission to NREL. Such additional initial validation is deemed

unnecessary and its absence is specifically noted if the entry material, including judgmental elements, is directly extracted from a published technical document that has already been subjected to peer review.

The NREL Manager now has the responsibility to validate the entry from a number of additional viewpoints, and to call for subsequent draft revisions until all of the acceptability checks have been satisfied. A preliminary checklist (during this design and initial implementation phase) consists of the following:

- Accuracy requirements met (discussed directly above).
- Consistency standards met relative to other entries (see discussion in Subsection 2.3).
- Mandatory bibliographic, version control and interpretive information requirements met (see discussion in Subsection 2.3).
- Requirement met for entry to effectively communicate information that is accurate, consistent and understandable.

The first three of these validations are relatively straightforward. The fourth validation, while judgmental, is the key to successful implementation of the BDRS.

Based on past experience, significant difficulties in arriving at consensus views among team participants are viewed as highly unlikely. However, one final procedural step may be taken if required. Any team participant may appeal a particularly intractable issue to the head of the Biofuels Program at the Department of Energy Headquarters. The decision of that individual will be final.

The above procedures are devised to accomplish the following objectives:

- Initial responsibilities for topic identification, selection and drafting, as well as assurance of accuracy, consistency and understandability, are highly decentralized among team participants;
- Dispute resolution and internal peer review procedures are integral to the process but only called for on an as-required basis;
- No single participant can exert an untoward degree of influence on the content of the system; and
- The final resolution authority and responsibility of the Federal head of the Biofuels Program can be invoked if this should ever prove to be necessary.

Adaptation of the above procedures to the remaining types of managerial actions is self-evident. These additional decision areas include such matters as proposals to add or delete categories, or to modify the structure, or to upgrade or delete an existing entry.

The NREL Manager is also responsible for housekeeping types of activities. These include:

- Maintaining a log of BDRS-related activities and archiving appropriate information on the status of its content over time.
- Ensuring that references in the entries to original data sources result in an addition to a master BDRS Bibliography listing.
- Acquiring and maintaining, to the degree feasible, electronic versions of original data sources, so that these may be readily accessed by interested users.
- Distributing (or making user access possible for) BDRS entries, as well as communicating and controlling information on the structure and use of the system.
- Establishing mechanisms for user feedback which will facilitate improvement of the system over time, and verify that its objectives are being met.

With the above understanding of purpose, users, design criteria and business management procedures, it becomes possible to propose a specific structure, categories and distributional approach. These topics are discussed in the next section of this report.

3.0 Initial Implementation

3.1 Introduction

The BDRS was originally conceived as being spreadsheet-based. However, the structure and categories proposed for the system are independent of the delivery medium.

Accordingly, when discussions with potential users took place as part of the design process, and a consensus developed for a Web-based system, the considerations involved in shifting from one delivery medium to another were examined. It was determined that all design criteria and business management procedures remained valid, and that no incompatibilities existed. Illustrative entries, suitable for either type of system, have been developed and are included in this report.

The distributional issues between the two types of systems are quite different, however, and need special consideration. It may be possible and desirable to operate both distributional processes in a parallel and synergistic mode.

The following subsections treat those subject matters in sequence. First, the proposed structure and categories of the BDRS are presented in the abstract, and then associated with its originally-planned spreadsheet format. Next, a discussion of the Web-based distributional approach is presented. Unique situations associated with proposed interactive entries (which are more difficult to accommodate in Web-based as compared to spreadsheet-based systems) are examined in some detail. Third, the illustrative system entries are described and discussed. In a final chapter of this report, proposed next steps in this initial implementation process are noted and discussed.

3.2 Proposed Structure and System Categories

The proposed hierarchical structure of the BDRS is presented in Figure 1. It is seen as a triangle, with specialized knowledge areas serving as the base for the program analysis activities, leading through increased levels of integration of the individual components to program management considerations which are based on analytic outputs, and which incorporate quantitative metrics in addition to subjective statements of program mission and goals.

This electronic Triangle of Analyses for Bioethanol is referred to here as eTAB!, in order to stress its electronic basis, and to suggest the ease with which spreadsheet tabs (or the equivalent HTML links) may be scanned in order to readily find specific pieces of information.

The concept of levels, shown in Figure 1, is intended to facilitate understanding as to where various kinds of information should be expected to exist within the system. A Level 0, not shown in the figure, describes the design and context of the system. Level 0 contains institutional and organizational information, whereas the main body of the system (Levels 1 through 7) contains the actual entries on the production and use of bioethanol in the United States.

In a spreadsheet-based system, each level is a separate file. The system uses the Microsoft Excel™ program as its medium. The Excel™ files are attached to this report as eTAB_Bk0.xls through eTAB_Bk7.xls. The titles of these books, once they are opened, are as follows:

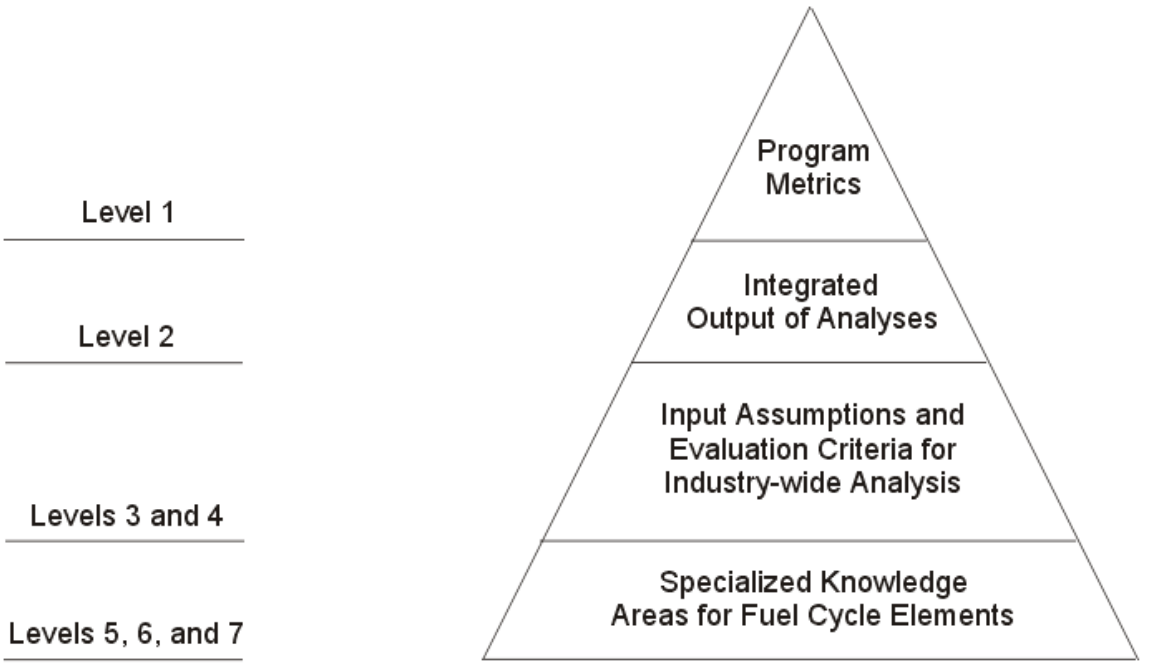
Book 0	Structure and Appendices
Book 1	Program Scope and Metrics
Book 2	Integrated Output
Book 3	Evaluation Factors
Book 4	Input Assumptions for Analysis
Book 5	Fuel Cycle Elements – Feedstock
Book 6	Fuel Cycle Elements – Conversion
Book 7	Fuel Cycle Elements – Demand

Each book (1 through 7) contains an Overview page for that book (which includes information on the structure of the book, its content, and how to operate it to locate information of interest) and a Bibliography of all references which appear in its entries. Book 0 contains a similar introduction for the entire system, and a total system Bibliography that combines all of the individual Bibliographies of the other seven books.

Each book is divided into two to four main Categories, which are, in turn, subdivided into Topic Areas associated with these Categories. For example, one of the Categories in Book 1 (Program Scope and Metrics) is Strategic and Program Plans. Under this latter heading, the Topic Areas are:

- Missions and Objectives
- Program Milestones
- Quantitative Metrics

Figure 1
Structure of eTAB!



The electronic Triangle of Analysis for Bioethanol — eTAB

Each Topic Area is a separate spreadsheet page, and is identifiable by a tab which contains its name. Introductory material appears at the top of the page to verify for the user the type of information which appears on the page. Individual entries are numbered and titled (to describe their contents in a summary fashion), and appear in descending order on the page.

A complete listing of categories and topic areas by level (or book) is provided as Appendix A. The Topic areas within each category are alphabetized so that they can be located easily and quickly.

The complete list of operating instructions (which rely entirely on the embedded Excel™ program menu) is as follows:

- To access any page that is not currently visible:
  - Select Format – Sheet – Unhide from MENU

- To search for information by keyword on any given page:
  - Select Edit – Find from MENU

Standardized color coding is specified for certain kinds of cell entries, particularly those intended for user interaction, as a means of making it simpler for the user to take advantage of the spreadsheet interface. This information, along with the above operating instructions, appears as part of the Overview material for each level.

This structure, even though it is apparently frozen within a spreadsheet format, is simple to modify. Categories and Topic Areas may be added or deleted by adding or deleting pages. Spaces for individual entries on a page may be opened up or removed by adding or deleting rows. All of these modifications are routine operations within the spreadsheet format.

The eTAB! files attached to this report are operable and complete, insofar as the structure is concerned. Completion of the system requires the insertion of information entries under the various topic areas. This may be accomplished at whatever pace is deemed appropriate, giving the first attention to priority topics.

Distribution of the completed material was originally visualized as taking place electronically (e.g., via email or high-volume disks), with maintenance and upgrading scheduled on a periodic basis (e.g., two to four times a year). When an earlier version of this system was discussed with potential users (in a meeting held at the offices of Technology & Management Services, Incorporated, in Gaithersburg, Maryland, on October 7, 1999), the structural concepts appeared to be acceptable, but a strong consensus developed to modify the media and distributional approach so that the system could be made Web-based, and thereby accessed remotely. The consequences of this modified approach are discussed in the next subsection.

3.3 The Web-Based System

Up to this point in the report, a fixed medium (disk-based) system has been described. However, the information content of this system consists of individual elements of information which are hung like ornaments on the branches of a tree-like structure. Accordingly, the entire system (structure, Categories and Topic Areas) is fully adaptable to a system which is accessed remotely by a user through the Worldwide Web.

Similarly, the recommended Business Management Procedures are directed at the selection, validation, maintenance and periodic upgrading of the individual information elements. Therefore, these procedures are also immediately adaptable to a Web-based system.

This study assumes that the BDRS, when configured on the Web, would be maintained on an appropriate Website at NREL. Since procedures for managing that site would be institutionally determined, discussion of such procedures is unnecessary and outside the scope of this report.

Clearly, a Web-based system, in which search and transportation from one location in the system to another is through hyperlinks, could and would update Topic Areas much more frequently than a fixed medium system since distribution of these updates to users is unnecessary. Users will find them as needed when they search those sections of the system where updates have taken place. This greater frequency of update is one of the superior attributes of the Web-based system.

The other major benefit of a Web-based system is the ability to be accessed remotely. This latter aspect will require control of that access, since some information elements in the BDRS may be reflecting sensitive material or work in progress among analysis team participants which is not intended for use by the general public. Much of the system content should be

suitable for general distribution, however, and usable as an important adjunct to ongoing program outreach activities.

The issue of perhaps greatest significance is the possibility that some potential characteristics of the presentation of information elements may become more complex and difficult under conditions of remote access. The original concept envisioned different kinds of entries which would emphasize, as appropriate to the data area, the use of text, graphics, and interactive demonstration, either singly or in combination. Text and graphics present no barriers to remote access, but interactive material does under certain circumstances. These circumstances have been examined, and the results of this review are discussed in the next several paragraphs of this report.

Microsoft Office™ is currently in wide use throughout the technical community. Microsoft has attempted to be a leader in integrating the components of the suite of programs in Office™ with the Web. Accordingly, the remote interactivity aspects of Microsoft Excel™ , the spreadsheet element, are believed to be superior to those currently available in any other product. This situation will, of course, change over time as other manufacturers and programs pursue similar capabilities. Nevertheless, it is recommended that initial implementation of the BDRS be designed to take advantage of the capabilities offered in the current Microsoft products.

The dilemma posed by the above recommendation is that not all potential users are able to access the most advanced features. Either these features are not included in the system (which is a loss to those who could access and use them) or some users will not immediately obtain the benefit. This problem can be minimized if non-interactive versions of the selected topic areas are also made available, with the interactive material possibly being treated as an add-on capability for those who have the means to reach it.

There are two elements required to remotely view interactive material: the software to operate it and the browser required to see it. If the software is to be Excel™, as is recommended here, the browser must be Internet Explorer 5.0 (version 4.0 will not work). Fortunately, this browser can be downloaded or otherwise obtained for free from many different locations by anyone with Web access. By definition then, the need to use this browser need not be a barrier to any serious intended user of the system.

The situation with the software is more difficult. First, authoring on the Web of a remotely interactive Excel™ module is only possible currently with Web authoring files incorporated into Microsoft Office 2000™ Premium. Other versions of the suite (such as Small Business edition and Standard) do not contain these files. Second, the ability to remotely manipulate the resulting interactive module requires Microsoft Office 2000™ Standard or Professional. (The 2000™ Small Business version does not support such manipulation, nor does any earlier version of the software suite such as Microsoft Office 97™.)

As time passes, it seems reasonable to assume that these barriers will disappear or diminish in importance, given the general history of the continual upgrading of computer software. Therefore, it is recommended that the BDRS be positioned at the leading edge of available technology (including the interactive capability), recognizing that some users will not be able to immediately access the entire system.

For completeness, we summarize below the specific remote actions available to a user of this technology which would normally be exploited in interactive information elements.

- Ability to search for keywords on the Excel™ page (within the element itself) as compared to the more general search across elements which is typical of the Web;

- Ability to read equations in cells;

- Ability to type over an input value on the Excel™ page and instantly see both a recalculated result and a revised graphical display of that result;

- Ability to sort a data set according to specified user criteria; and

- Ability to export the Excel™ page intact to the user's own computer without loss of its interactive features.

Numerous other commands are available but may not be as important as those listed above.

Needless to say, the Web-based files, while they can be remotely manipulated by a user, cannot be saved in altered form on the host Website.

By way of limitations, not every Excel™ command is available interactively; however, those that are not yet implemented in current versions are either rarely used or not of particular interest for remote interactivity. Only a single Excel™ page (not the entire workbook) may be saved in Web format for interactive use. This is not viewed as a limitation, however, since the intent is to embed graphics on the page rather than to present them as separate pages.

There is an important intermediate situation. With Internet Explorer 5.0, it is possible for a user to export an Excel™ spreadsheet from the Web to the user's own computer and save it there under another name. The user can subsequently manipulate this file in any way desired, and can explore its interactive features as if it had been received through a disk-based system.

A final recommendation for the Web-based system is to make it as visually interesting for the user as possible. In this regard, Microsoft now offers a desktop authoring application that lets users of the software add Internet multimedia features to Office™ documents without the need for HTML coding. The application is named Vizact 2000, and is used to publish Word™, Excel™, Outlook™ and other Office™ files on the Web that include images, animation and interactive bullets. Vizact 2000 also requires the use of Internet Explorer 5.0. Illustrations of Vizact's features can be found at www.microsoft.com/visact/product_overview.

The next subsection of this report presents a set of illustrative information entries for the BDRS system which extend from text only to fully interactive, such that the potential range of the system can be better visualized.

3.4 Illustrative Information Entries

Illustrative Information Entries have been prepared, one for each major section (level) of the system. These are summarized by Level, Category and Topic Area in Table 1.

The text only entries are included in sequence as Appendix B to this report. All others are embedded in the Excel™ Workbooks in order to display the graphics and/or interactivity. All illustrative entries may be transformed into Web-based files by using the "Save As HTML" command (or its current equivalent) from their respective applications, Word™ or Excel™.

In addition to the illustrative entries, the Overview to each workbook has been embedded, along with the bibliographic material required by the illustrative entries. Finally, the abbreviations used to date in the workbooks and entries have been embedded in the Level 0 workbook in the Appendices Category and Topic Area Abbreviations.

The interactive information entry on Conversion will be placed in February 2000 on the TMS Website (tms-hq.com) as an illustration of the Web functionality for an entry of this type.

4.0 Next Steps

The experience of creating illustrative information entries has shown that it is a time consuming process to simultaneously ensure that information is:

- Up to date,
- Stated accurately from a technical standpoint,
- Understandable to interested parties who may not be experts in the particular technical area,
- Free from unexplained jargon, and
- Appropriately balanced between factual information and program judgements or insights.

It is the opinion of the authors of this report that these requirements can be met. Therefore, the Bioethanol Data Reference System may primarily be viewed as a standard information source whose use is to be shared by all participants in the Bioethanol Program analysis process and the interested Department of Energy Headquarters and National Laboratory management structure. The BDRS can become the single source from which these personnel can quickly and easily obtain consistent, reliable data and program-related information.

An anticipated benefit of the system for the program will be an improved ability for program spokespersons to project a well-coordinated and credible story about the role that cellulosic ethanol can play in achieving significant benefits for the nation. For example, the information in the BDRS should find ready use in program outreach activities, analytic studies and reports, speeches and presentations, strategic and program plan development, the selection of related metrics and the tracking of program milestones.

Table 1
Illustrative Information Entries

Key to Table

Level and Category
Topic Area
Information Entry
Type of Entry

Entries

0 – Appendices
Analytic Models
Brief Descriptions of Models
Text

1 – Strategic and Program Plans
Missions and Objectives
Headquarters Strategic Plan
Text

2 – Program Analysis of Market Development
Penetration by Date and Use
Study Cases for Emerging Ethanol Industry
Text, Tabular, Graphics

3 – Monetization of Costs and Benefits
Rural Revenues
Rural Revenue from Reference Study Cases
Text, Tabular, Graphics

4 – World Context Indicators
Oil Market Projections
Annual Energy Outlook Projections
Text, Tabular, Graphics

5 – Economic and Financial Factors
Inflation and Discount Rates
Gross Domestic Product (GDP) Deflators
Text, Tabular, Graphics

6 – Feedstock Production and Delivery
Energy Crops
Crop Rotation and Harvesting Cycles
Text

7 – Conversion
Process Costs
Cost Variability
Text, Tabular, Graphics, Interactive

8 – Demand and Use
Neat Fuel
Aviation Grade E85
Text

In addition, this information can be current, well-organized, easy to locate, available on a quick-response basis, and already validated through peer review.

Before these benefits can be achieved, a number of near-term actions remain to be considered:

- A formal assignment of responsibility to NREL for the completion and management of a Web-based system may be appropriate;
- Agreement should be reached as to the recommended Structure, Categories and Topic Areas being suitable for the initial full implementation of the system;
- A decision is needed as to the parallel maintenance of a spreadsheet-based set of workbooks (since the special values of this format can be retained without duplication, given the easy transportability of files from Word™ and Excel™ to Website and back again); and
- Continuing progress is required on the completion of information entries within the BDRS structure.

While initial plans called for the early development of a User's Manual, the few lines of instruction in each of the eTAB! Workbook Overview Sections is really all that is needed to operate that media. For a system installed on the NREL Website or its equivalent, guidance on how to access the BDRS material should be compatible with related institutional procedures, and its preparation is outside the scope of this report.

Given the illustrative information entries already in place, it is recommended that priority be given to adding the next set of entries within the following Categories and Topic Areas:

- Level 0 – Appendices, Participants of Analysis Team
- Level 1 – Strategic and Program Plans, Missions and Objectives, Bioenergy Initiative (Entry Title)
- Level 1 – Regional Biomass Energy Program (RBEP) Plans, Headquarters Level
- Level 2 – Program Analysis of Market Development, Early Year Plants
- Level 2 – Program Analysis of Market Development, Penetration by Date and Use
- Level 3 – Environmental Emissions, Greenhouse Gases (GHG)
- Level 3 – Monetization of Costs and Benefits, Costs of Incentives
- Level 4 – Current and Historical Data, Capacity and Production
- Level 4 – World Context Indicators, Greenhouse Gas (GHG) Projections

- Level 5 – Feedstock Production and Delivery, Agricultural Residues, Corn Stover (Entry Title)
- Level 6 – Conversion, Process Costs, Impact of Technology on Cost (Entry Title)
- Level 7 – Demand—Vehicles and Devices, Fuel Cells

It is emphasized that individual entries are expected to be brief treatments, similar to the illustrative material already created. However, over time, the accumulation of numerous entries will gradually result in the existence of an impressive body of interconnected information, easily accessible by a wide range of users.

It is estimated that individual entries can be prepared in a few hours in some cases (essentially a summary, in text form, of insights developed in a larger published document) and will require up to several days in extreme cases (broad subject matter, reference material not well organized, complex judgement area, much tabular and/or graphical material needed to explain the area).

Across a broad range of topics, an average time of 8 hours to prepare an entry may prove to be reasonable. More experience is required before a definitive view on this matter can be presented.

While some time may yet be required to fully resolve some of the details of the BDRS and its delivery system, it is recommended that work proceed expeditiously on the continuing creation of validated information entries.

Appendix A

ETAB! Structure, Categories and Topic Areas

Appendix A
ETAB! Structure, Categories and Topic Areas

Level 0 – Structure and Appendices

- Overview
  - Structure
    - Design Criteria
    - Management Procedures
  - Appendices
    - Abbreviations
    - Analytic Models
    - Participants of Analysis Team
    - Topic Index
- Bibliography

Level 1 – Program Scope and Metrics

- Overview
  - Strategic and Program Plans
    - Missions and Objectives
    - Program Milestones
    - Quantitative Metrics
  - Regional Biomass Energy Program (RBEP) Plans
    - Great Lakes
    - Headquarters Level
    - Northeast
    - Pacific Northwest & Alaska
    - Southeast
    - Western
  - Related Program Areas
    - Biodiesel
    - Biopower
  - Joint Activity with Other Agencies
    - Energy Information Administration (EIA)
    - Environmental Protection Agency (EPA)
    - US Department of Agriculture (USDA)
- Bibliography

Level 2 – Integrated Output

- Overview of Workbook
  - Program Analysis of Market Development
    - Early Year Plants
    - Incentives/Regulations
    - Local Considerations
    - Niche Market Information
    - Penetration by Date and Use

- Synergism with Biopower
- Synergism with Corn Industry
- Synergism with Paper/Pulp Industry
- Projections of Fuel Market Information by Others
  - Associations, Environmental Organizations
  - Energy Information Administration (EIA)
  - General Accounting Office (GAO)
  - Industry Performers
  - International Energy Agency (IEA)
  - Other Nations
  - Policy Office of the Department of Energy
  - States & Regions
- International Production and Use
  - Asia
  - Brazil
  - Canada
  - Europe
  - Joint Activity
  - Other Nations
- Bibliography

Level 3 – Evaluation Factors

- Overview of Workbook
- Environmental Emissions
  - Carbon Monoxide
  - Greenhouse Gases (GHG)
  - Nitrogen and Sulfur Oxides (NO_x & SO_x)
  - Ozone Precursors
  - Particulates
  - Toxics and Other Health Impacts
- Market Impacts
  - Corn-Based Bioethanol
  - Domestic Oil Industry
  - Energy Security & Import Displacement
  - Net Employment – National & Regional
  - Shared Use of Cellulosic Feedstocks
  - Trade Balance Considerations
  - World Bioproducts Industry
- Monetization of Costs and Benefits
  - Benefit/Cost Ratios
  - Costs of Incentives
  - Non-Market Benefit Values and Offsets
  - Non-Market Costs and Offsets
  - Regional Benefit/Cost Issues
  - Rural Revenue
- Bibliography

Level 4 – Input Assumptions for Analysis

- Overview of Workbook
  - Current and Historical Data
    - Capacity and Production
    - Cost
    - Market Use
    - Technology
  - Economic & Financial Factors
    - By-Product Credits
    - Capital Recovery
    - Inflation & Discount Rates
    - Insurance and Taxes
  - Risk Factors
    - Contracting Issues
    - Cost and Performance Assurance
    - Feedstock Supply
    - Market Uncertainties
    - Technology Obsolescence
  - World Context Indicators
    - Greenhouse Gas (GHG) Projections
    - Oil Market Projections
- Bibliography

Level 5 – Fuel Cycle Elements – Feedstock

- Overview of Workbook
  - Feedstock Production & Delivery
    - Agricultural Residues
    - Energy Crops
    - Harvesting & Storage
    - Land and Land Use
    - Other Feedstocks
    - Transportation
  - Cross-Cutting Issues for Feedstock
    - Competition for Other Use
    - Economies of Scale
    - Environmental
    - Market Entry Constraints
    - Maximum Supply Constraints
    - Regulatory Constraints
    - Seasonality
    - Tradeoff Areas
- Bibliography

Level 6 – Fuel Cycle Elements – Conversion

- Overview of Workbook
  - Conversion
    - Alternative Technology Pathways
    - By-Product Production
    - Feed Preparation & Storage
    - Process Costs
    - Process Description
    - Product Definition & Specification
    - Product Transportation & Storage
  - Cross-Cutting Issues for Conversion
    - By-Product Markets
    - Design Philosophy Issues
    - Economies of Scale
    - Environmental
    - Future Viability
    - Market Entry Constraints
    - Maximum Supply Constraints
    - Regulatory Constraints
    - Seasonality
    - Tradeoff Areas
  - Bibliography

Level 7 – Fuel Cycle Elements – Demand

- Overview of Workbook
  - Demand & Use
    - Blend Fuel (E10 Standard or Lower)
    - Blend Fuel (Intermediate Levels)
    - Chemical Grade
    - Import and Export
    - Neat Fuel
    - Octane Enhancement
    - Oxygenate Values
    - Reformulated Gasoline (RFG) – Current
    - Reformulated Gasoline (RFG) – Future
    - Regional Issues
  - Demand – Vehicles and Devices
    - Combustion Devices for Blend Fuels
    - Combustion Devices for Neat Fuels
    - Fuel Cells
    - Other
  - Cross-Cutting Issues for Demand
    - Environmental
    - Infrastructure Needs
    - Manufacturers & Models
    - Market Entry Considerations
    - Market Growth Considerations

Appendix B

Illustrative Information Entries
(Text Only)

Appendix B
Illustrative Information Entries
(Text Only)

1. Entry for Level 0 (Structure and Appendices), Appendices, Analytic Models, Brief Description of Models

Participants in the Bioethanol Program analysis activity use a variety of different models and other computer-based analytic tools to examine details of the bioethanol fuel cycle, the fuels market, industry growth over time, and benefits associated with greenhouse gas mitigation and fuels import avoidance. Selected examples of these models are summarized below (in alphabetic order by their names or acronyms).

ESAS

The Ethanol Industry Evolution Systems Analysis Spreadsheet is a market-based supply and demand analysis of an emerging cellulosic ethanol industry. Energy crops and agricultural residues are competed, at five-year intervals (2000 through 2025), as feedstocks for continually improving conversion technologies. The resulting integrated supply curve for ethanol, including the current corn-based industry, intersects demands for ethanol in gasoline blends (e.g., E10) as an oxygenate, for its octane content, as a toxic and sulfur diluent, and as a neat (essentially pure) fuel such as E85. Economic benefits associated with the avoidance of greenhouse gases and transportation fuel imports are calculated and compared with costs to generate benefit-cost ratios. Year-by-year production and use of cellulosic ethanol over time are reported. ESAS was developed and is maintained by Technology & Management Services, Incorporated, of Gaithersburg, Maryland.

GREET

Argonne National Laboratory (ANL) has developed the GREET model. The acronym stands for Greenhouse Gases, Regulated Emissions and Energy Use in Transportation. GREET is a total energy cycle model which considers energy expenditures and gaseous emissions (including particulates) from activities needed to produce fuels as well as the vehicles which use them. GREET estimates per-mile energy use and emissions of fuel and vehicle combinations on a comparative basis. The Bioethanol Program uses GREET to evaluate these characteristics of ethanol fuel, both cellulosic-based and corn-based. Particular emphasis is placed on quantifying the benefits of greenhouse gas mitigation and fuel import avoidance.

NREL Discounted Cash Flow Model

The National Renewable Energy Laboratory (NREL) uses a spreadsheet-based Discounted Cash Flow Economic Model to evaluate the cost of conversion of cellulosic feedstocks to fuel grade ethanol. A process design is developed externally to the model, and the key process characteristics, including process equipment requirements, process yields, and the like, are input to the model. Estimation of construction and operating costs (both fixed and variable) takes place within the model. Capital financing parameters are assumed, and the resulting costs discounted through time. The discounted revenue stream needed to equalize the discounted costs and revenue streams is determined. By this technique, an annual

operating cost (price) for the ethanol product is determined, which recovers all expenses as well as both the capital investment to construct the plant and a return on that investment compatible with other facilities in the chemical processing industry.

ORNL Refinery Yield Model

The Oak Ridge National Laboratory (ORNL) Refinery Yield Model (RYM) is a spreadsheet-based program which simulates various regional crude oil refining configurations. It is a linear program (a technique for solving numerous simultaneous system requirements and restraints to produce an optimized result) which can incorporate 50 different refining processes, and produce 40 different products from more than 100 crude oils. The Bioethanol Program uses the RYM to derive relationships between the cost of ethanol and its value to a refiner and/or blender based on its oxygenate, octane enhancement, and fuel extender characteristics.

POLYSYS

POLYSYS is an agricultural sector model developed and maintained by the Agricultural Policy Analysis Center at the University of Tennessee. It contains the major agricultural crops, and livestock, and has now been modified to incorporate energy crops (switchgrass and short rotation woody crops such as willows and hybrid poplar). The model uses a high level of detail (305 U.S. Agricultural Statistical Districts) to provide economic and land use results at state, regional and national levels. The model is being used by the Bioethanol Program to evaluate the costs and quantities of energy crops that may be grown on cropland acreage throughout the US.

TAFVM

The Transitional Alternative Fuels and Vehicles Model (TAFVM) was developed at Oak Ridge National Laboratory. It simulates the use and cost of alternative fuels and alternative fuel vehicles in a near- and mid-term time frame. The model is designed to examine the transitional features of expanding alternative fuels use as well as the competition among the various candidate fuels and vehicles for that market. As a matter of emphasis, the model is specifically designed to evaluate the effects of various types of incentives on the future prices, availability and penetration rates of alternative fuels vehicles.

Created on January 28, 2000

Sources:

Hadder, G.R., Ethanol Demand in United States Gasoline Production, Oak Ridge National Laboratory ORNL-6926, November 24, 1998

Leiby, Paul et al., The Alternative Fuel Transition (Review Edition), Oak Ridge National Laboratory, February 27, 1998

Technology and Management Services, Ethanol Industry Evolution Systems Analysis Spreadsheet (ESAS) – Documentation and User's Manual, December 1, 1998

Walsh, Marie, et al., Evolution of the Fuel Ethanol Industry: Feedstock Availability and Price (draft), Oak Ridge National Laboratory, October 26, 1998

Wang, Michael, Fuel-Cycle Energy and Emissions Impacts of Fuel Ethanol, Argonne National Laboratory, Presentation to the National Research Council, December 17, 1998

Wooley, Robert et al., Lignocellulosic Biomass to Ethanol Process Design and Economics, National Renewable Energy Laboratory, July 1, 1999

2. Entry for Level 1 (Program Scope and Metrics), Strategic and Program Plans, Missions and Objectives, Headquarters Strategic Plan

Strategic Goals (Missions) of the United States Department of Energy include the following:

- Improve the Economic Efficiency of the Energy System Supply and Use to Enhance Overall Performance of the US Economy.
- Reduce the Vulnerability of the US Economy to Disruptions in Oil Supply.
- Ensure Energy Systems Reliability, Flexibility, Emergency Response Capability, and Risk Management.
- Reduce Pollutants and Greenhouse Gas Emissions.
- Enhance Sustainable Global Economic Development.

A viable cellulosic ethanol production industry and the use of bioethanol as a transportation fuel, both in the United States and worldwide, can make positive contributions simultaneously to all of these goals.

In order to support these goals, the Bioethanol Program funds mid-term and long-term high-risk research and development activities to lower the U.S. dependency on foreign oil, promote economic growth through domestic energy production, and reduce carbon emissions.

Specific objectives (which are periodically updated and modified) include:

- Develop cost-competitive biomass feedstock supply systems to support large-scale wide-spread production of fuels, chemicals and power from agricultural and forest residues, and energy crops.
- Develop integrated bioengineering systems to increase conversion yields and reduce bioethanol production costs.
- Foster, through regional program activities, the use of bioenergy alternatives through technology transfer and industry support at the state and regional levels.
- Integrate and coordinate biomass programs within the U.S. Department of Energy, and with industry, the U.S. Department of Agriculture and the Environmental Protection Agency to support bioenergy industry growth.

Created on January 28, 2000

Source:

Santos-Leon, Gerson, Program Element: Office of Fuels Development, Office of Transportation Technologies, Presentation to Energy Resources Portfolio Panel, June 2, 1999.

3. Entry for Level 5 (Fuel Cycle Elements – Feedstock, Feedstock Production and Delivery, Energy Crops, Crop Rotation and Harvesting Cycles

Energy crops are those plantings grown deliberately to serve as input feed materials (feedstock) for the production of biomass-derived (cellulosic) energy fuels such as ethanol. Typical energy crops of current interest in the U.S. are switchgrass, willows, and hybrid poplars. All of these crops have rotation periods between plantings and time delays prior to harvesting within those rotation periods for the crops to mature.

Switchgrass has a rotation period of ten years, is a perennial, and harvesting can begin in one year in some locations and two years in others.

Willows have a rotation period of twenty-two years. The first harvesting can begin some four years after planting, with subsequent harvests on a three-year cycle.

Hybrid poplars grow to harvest maturity in six years in the Pacific Northwest; in eight years in the Southeast, Southern Plains and South Central regions; and in ten years in the Corn Belt, Lake States, Northeast and Northern Plains regions.

Entry created on January 28, 2000

Source:

Walsh, Marie, Oak Ridge National Laboratory, Private Communication with TMS, Inc., January 14, 2000

4. Entry for Level 7 (Fuel Cycle Elements – Demand), Demand and Use, Neat Fuel, Aviation Grade E85

The Federal Aviation Administration (FAA) approved Aviation Grade E85 (AGE85) in May 1999 for use in Cessna 180 series piston aircraft. AGE85 is a blend of 87 percent ethanol, 12 percent pentane isomerate (a high-octane gasoline blendstock), and 1 percent Biodiesel. The FAA certification is based on flight tests and engine teardowns which demonstrated fuel acceptability with respect to FAA standards for performance, materials compatibility and engine wear requirements.

Testing of additional aircraft is in progress, and is expected to lead to certification of AGE85 for use in additional U.S. aircraft as tests are completed. The total U.S. demand for general aviation fuel is about 300 million gallons per year of fuel according to a 1998 FAA estimate.

However, AGE85 is about 15 percent less efficient (per gallon) than conventional aviation gasoline, and therefore would require a slightly higher level of usage for displacement.

With ethanol selling at $0.95 per gallon, AGE85 is expected to sell for $1.10 per gallon at the pump, substantially below the cost of conventional aviation gasoline at $2.00 per gallon. (All economic data in this paragraph are reported as of December 1999.)

Conventional aviation gasoline contains lead. Hence, in addition to reduced greenhouse gas emissions and overseas oil dependency, the displacement of conventional aviation gasoline by AGE85 would also reduce the human health risks associated with exposure to this element.

AGE85 was developed by the University of North Dakota's Energy and Environmental Research Center (EERC) which may be contacted for additional information.

Entry created on January 28, 2000

Sources:

Oxy-Fuel News, December 20, 1999
Carbohydrate Economy, Fall 1999

Economic data: Presumed to be Year 1999 Dollars

5. Note that Illustrative Entries for other Levels (2, 3, 4 and 6) are embedded in their respective workbooks, attached as electronic files to this report.